

Black hole - host galaxy coevolution in IMBH regime

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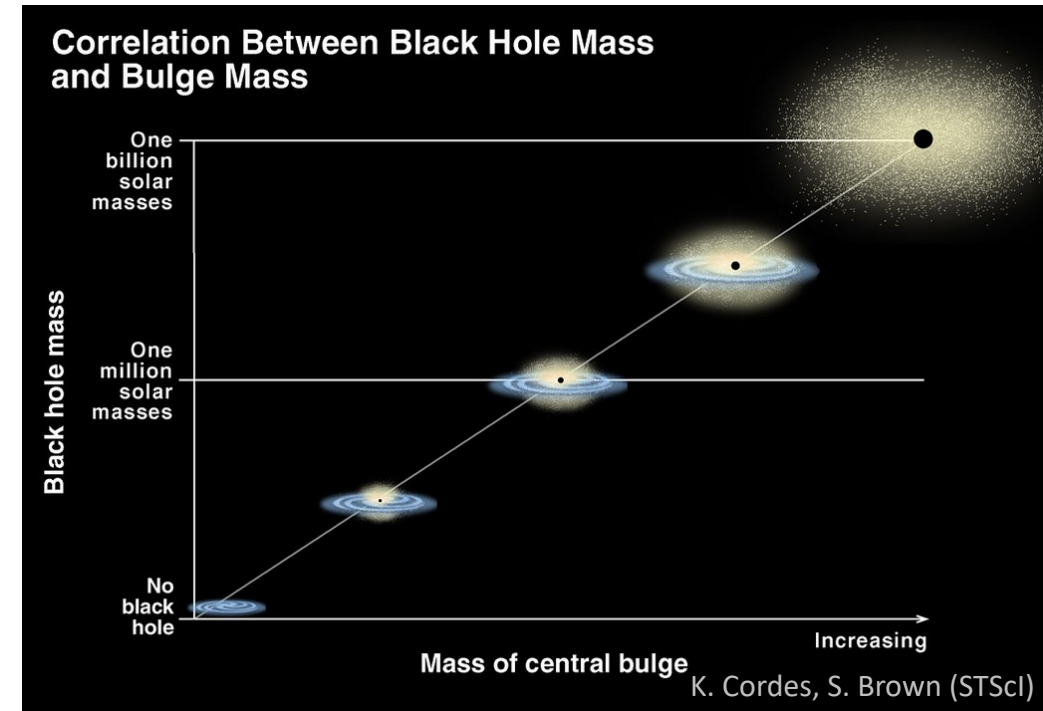
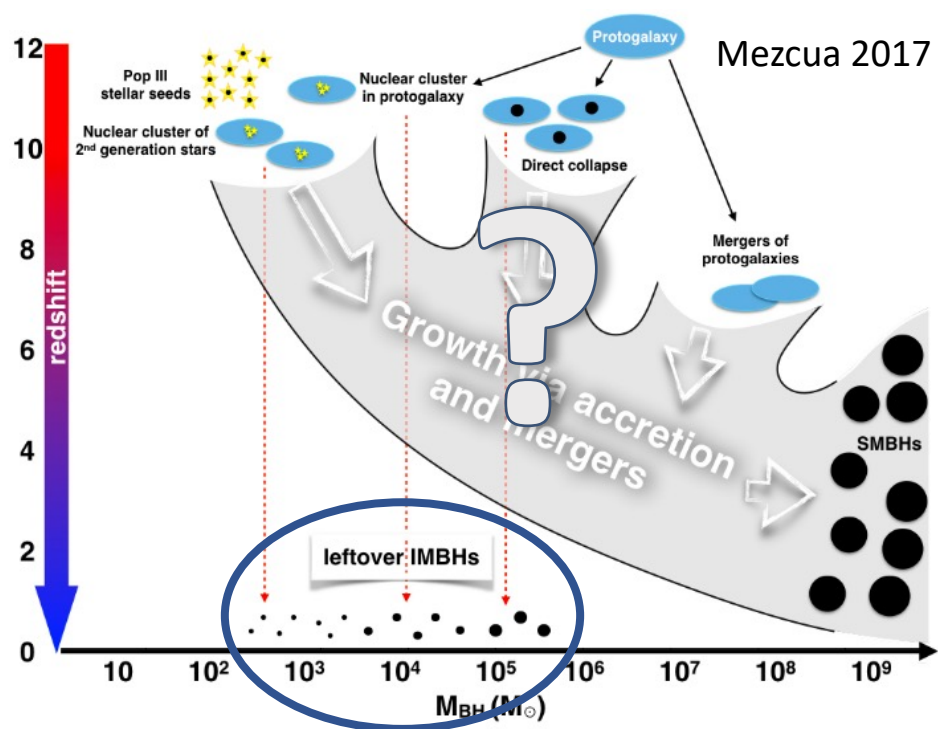
on behalf of:

Igor Chilingarian, Ivan Katkov, Victoria Toptun, Françoise Combes, Ivan Zolotukhin, Franz Bauer, Evgenii Rubtsov, Mariia Demianenko, Liana Osipova, Fedor Kolganov, Daniel Fabricant, Roberto Soria, Alister W. Graham

What are the IMBHs and why are they important

The most of massive galaxies are expected to host a Supermassive Black Hole (SMBH) in its center. The main questions: how these SMBHs were formed/what were their seeds and how they grew/evolved over the cosmic time.

- IMBHs in the local Universe can help if (we assume that) they evolve now similarly to high-z IMBHs
- Search for low-z type-I AGN powered by IMBHs in SDSS
- Spectroscopic selection + multi-wavelength follow-up



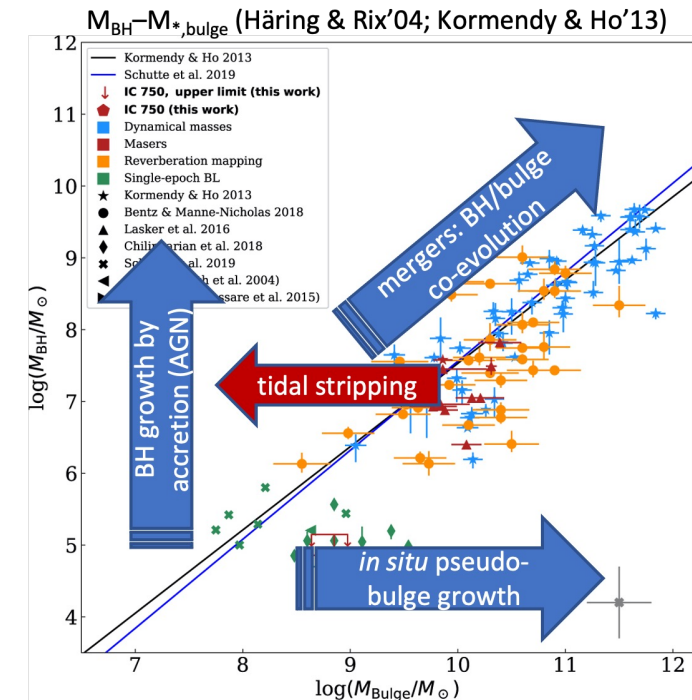
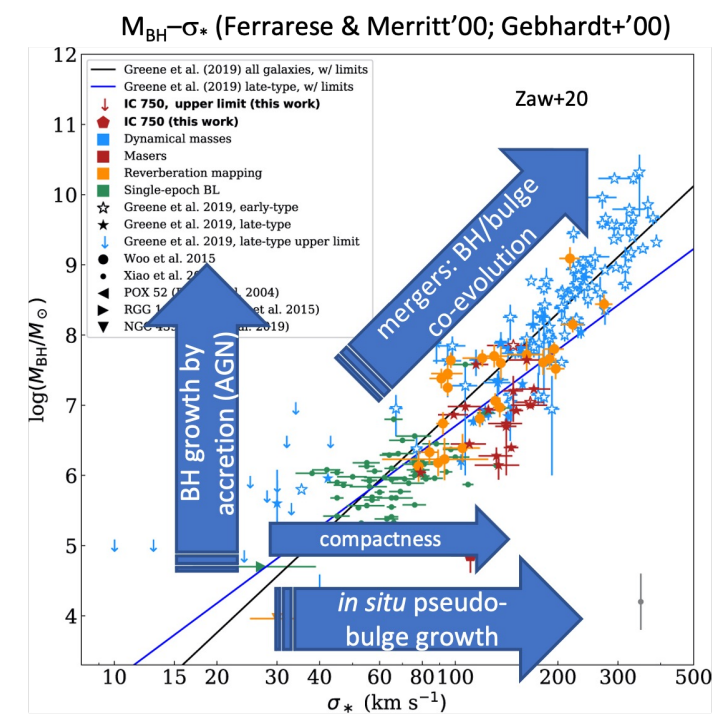
Central BH and host galaxy coevolution

A pseudo-bulge growing *in situ* (Kormendy & Kennicutt'04): no correlation with BH expected, usually pseudo-bulges are more massive than expected for such M_{BH} .

With mergers, bulge and BH grow similarly, leading to a correlation between M_{BH} and M_{bulge} , σ^*

In accretion-dominated case M_{BH} is larger than expected for such a bulge

Tidal stripping reduces M_{bulge} , but does not affect much σ^*

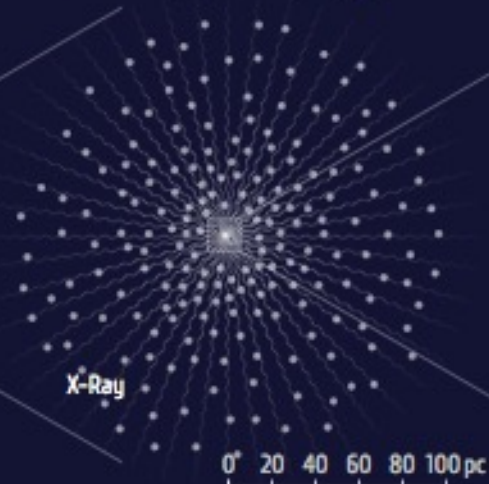


Galaxy with an AGN

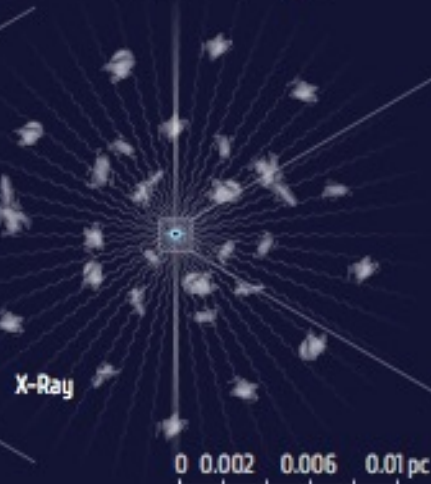


0 5 10 15 20 kpc

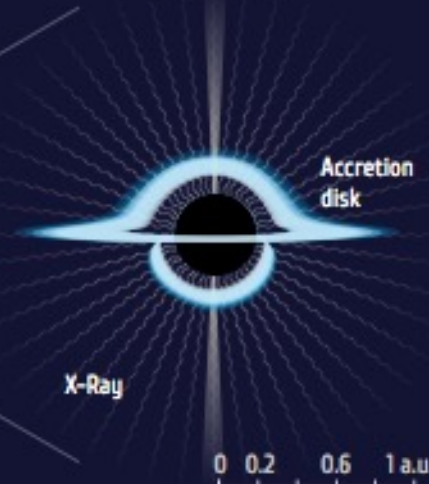
NLR — narrow line region



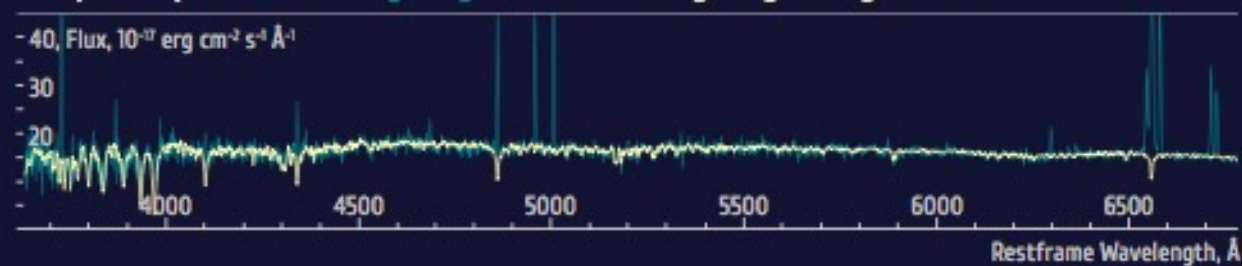
BLR — broad line region



Black hole



An optical spectrum of the galaxy centre and the galaxy starlight model

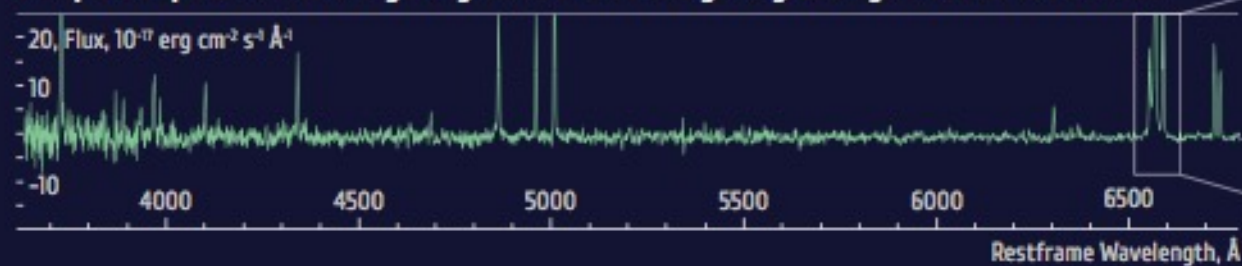


H α + [NII] emission lines

Nonparametric narrow line model
Gaussian broad line model

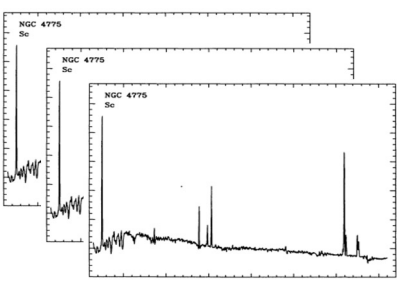


An optical spectrum of the galaxy centre with the galaxy starlight model subtracted

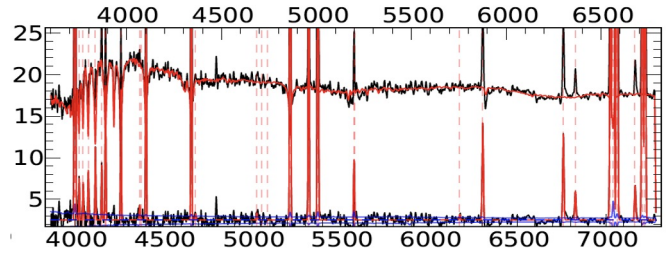
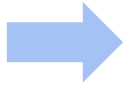


Narrow + Broad line model
Observations

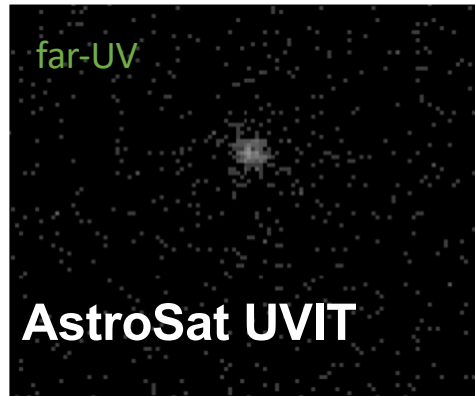
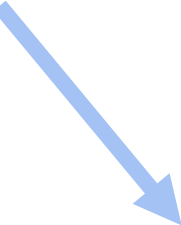
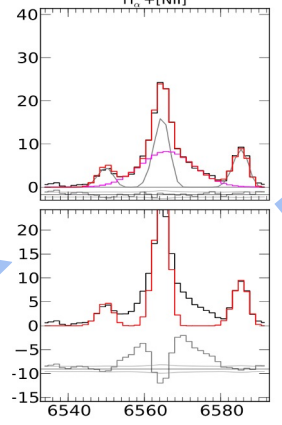




Input galaxy spectra



Stellar continuum model + emission lines



Search for active IMBHs

detecting broad-line signatures in galaxy spectra (optical type-I AGN) in RCSED spectra, then following them up
ApJ, Vol. 863, 1 (2018)

Monte-Carlo simulations

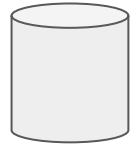
Testing with several epochs

Candidates

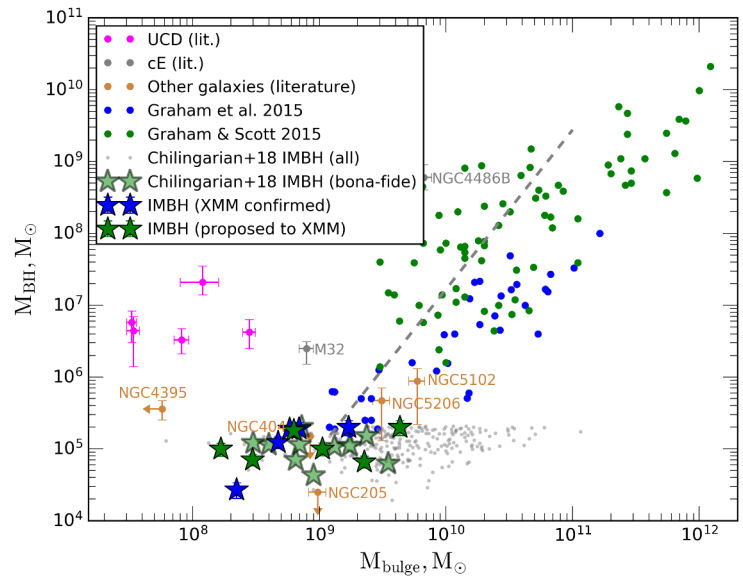
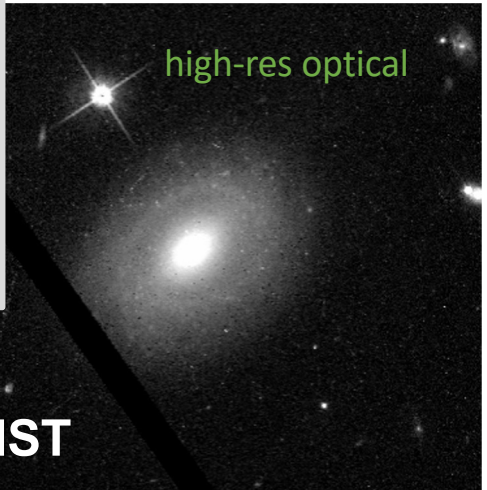
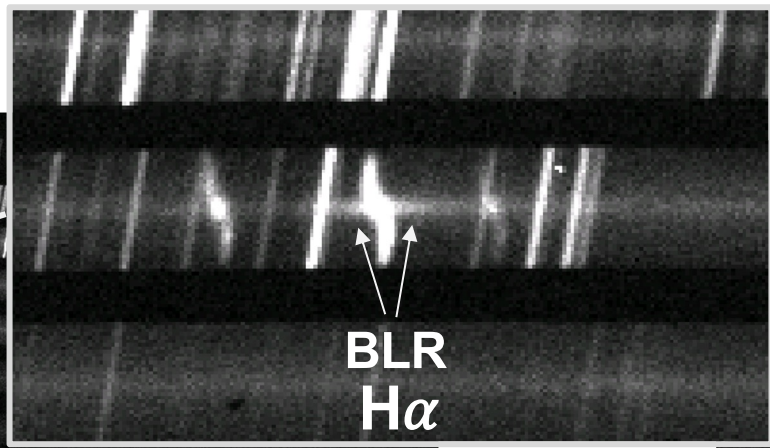
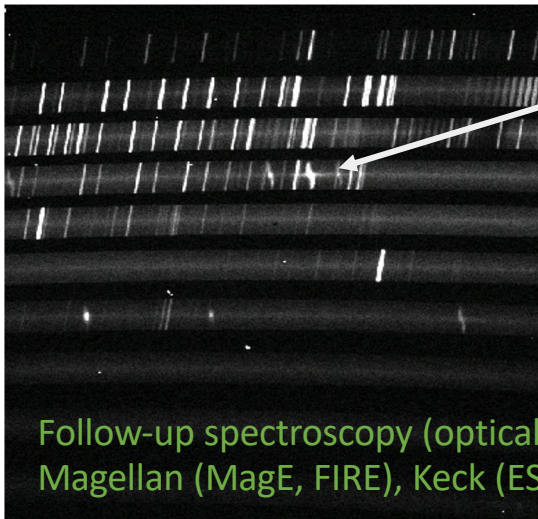
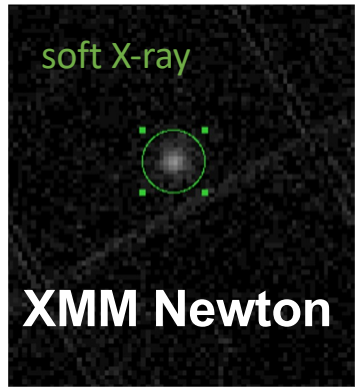
Filter

M_{BH}

Literature



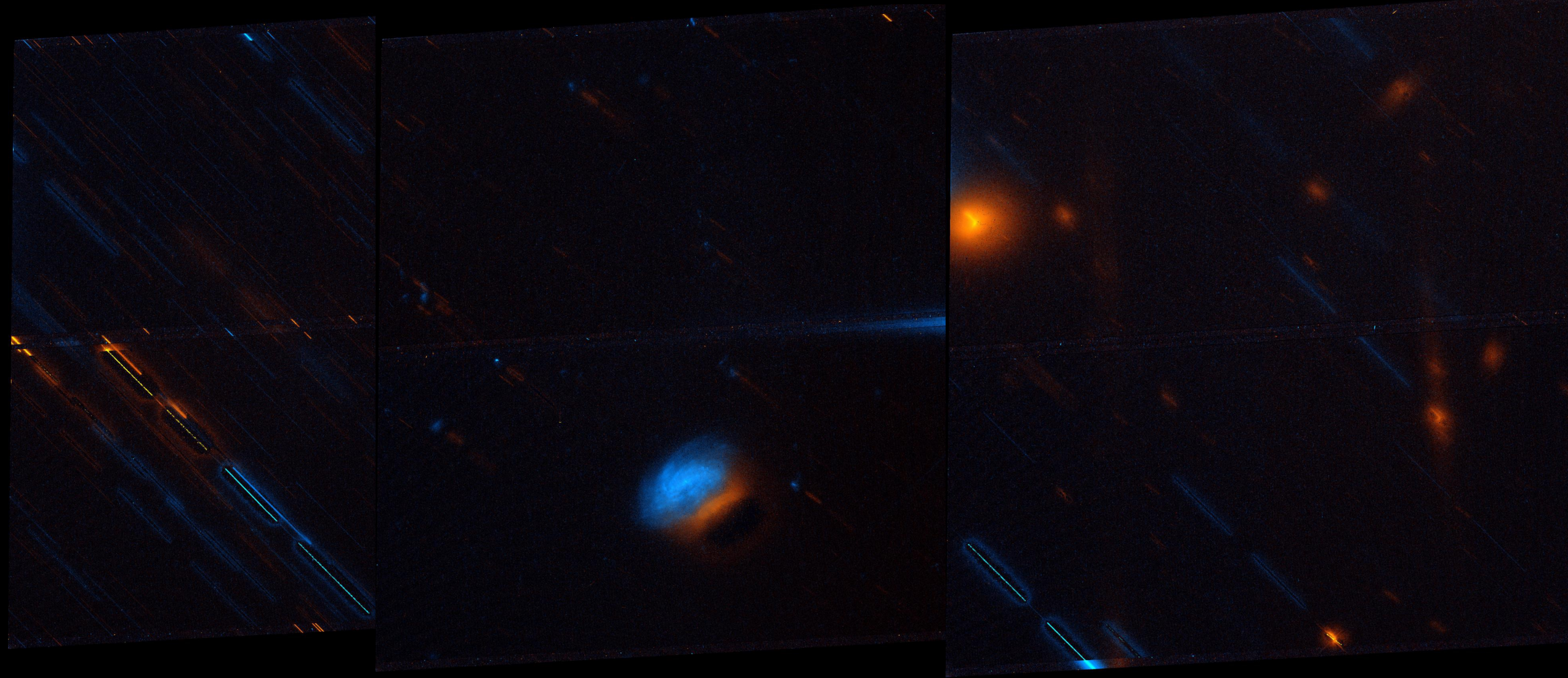
Virtual Observatory, data archives, X-ray upper limits



Our dedicated follow-up campaign with HST



Sometimes it does not go well...



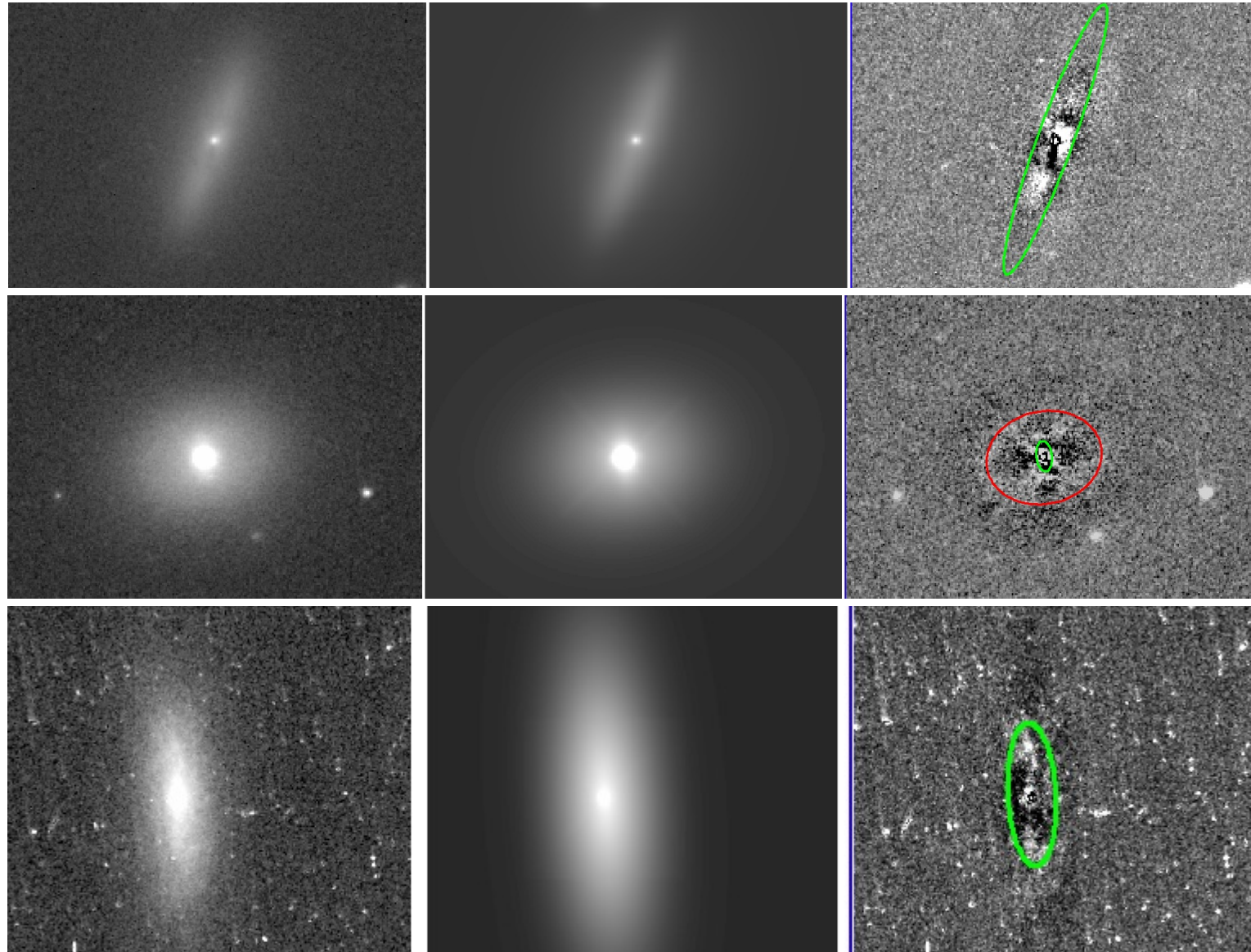
High-resolution imaging follow-up + archives: HST

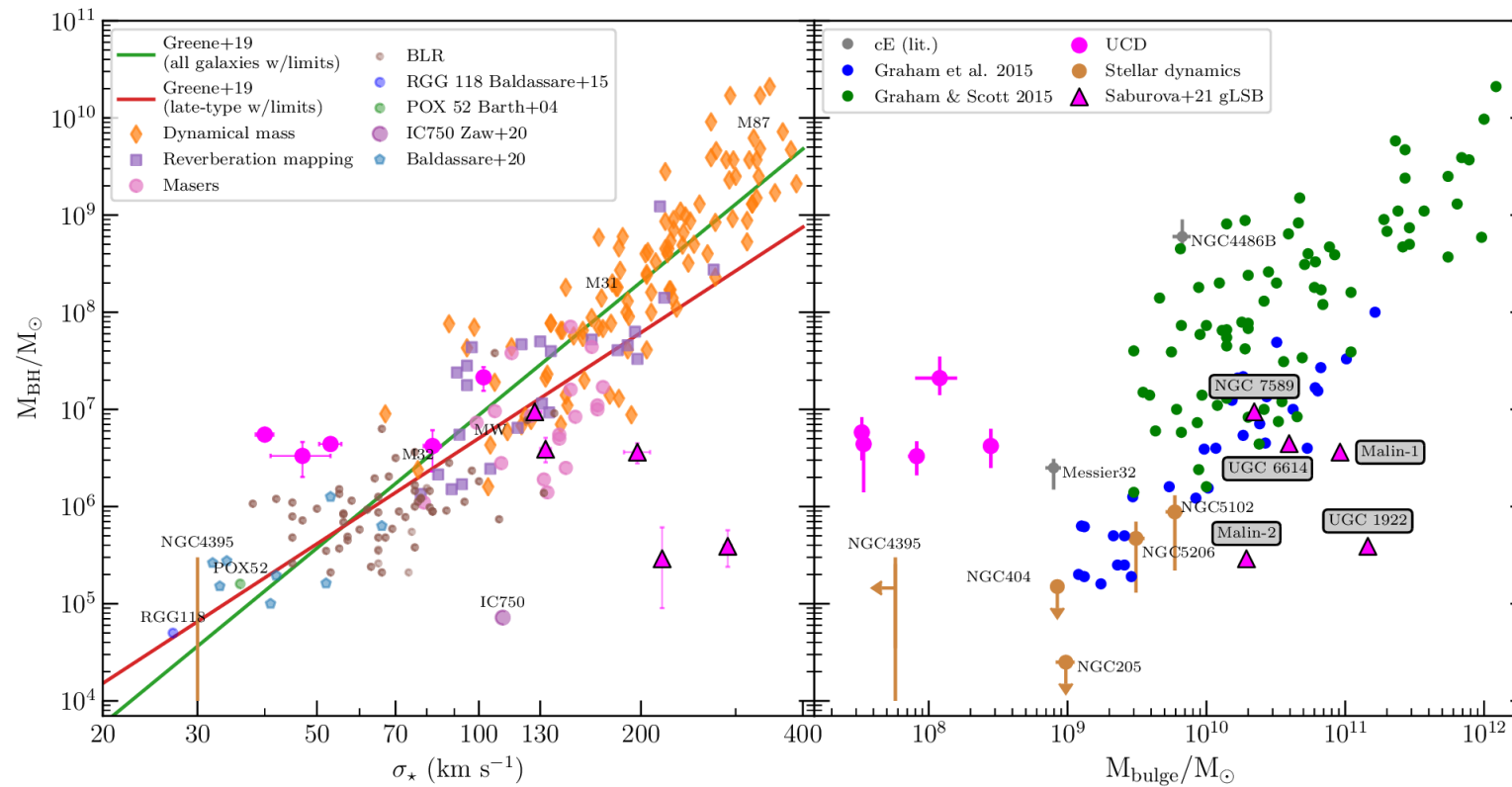
Out of ~ 1800 objects with $M_{\text{BH}} < 10^6 M_{\odot}$
76 have archival HST data.

We performed 2D modelling (GalFit) for all
galaxies observed using WFC3 that do not
show prominent spirals (e.g. elliptical
galaxies).

In the modelling procedure we mask
bright stars and dust lanes in the galaxies.

*HST Snapshot program for up-to 83 orbits,
3 bands (F300X/F475W/F814W)*





BH-Host
scaling
relations:
literature

Do IMBHs follow $M_{\text{BH}}-M_{*,\text{bulge}}$ relation?

- The position of IMBHs/their hosts on the scaling relation suggests the coevolution between central BH and hosting spheroids.

But don't we lose anything?

Some hints that the situation can be more complicated:

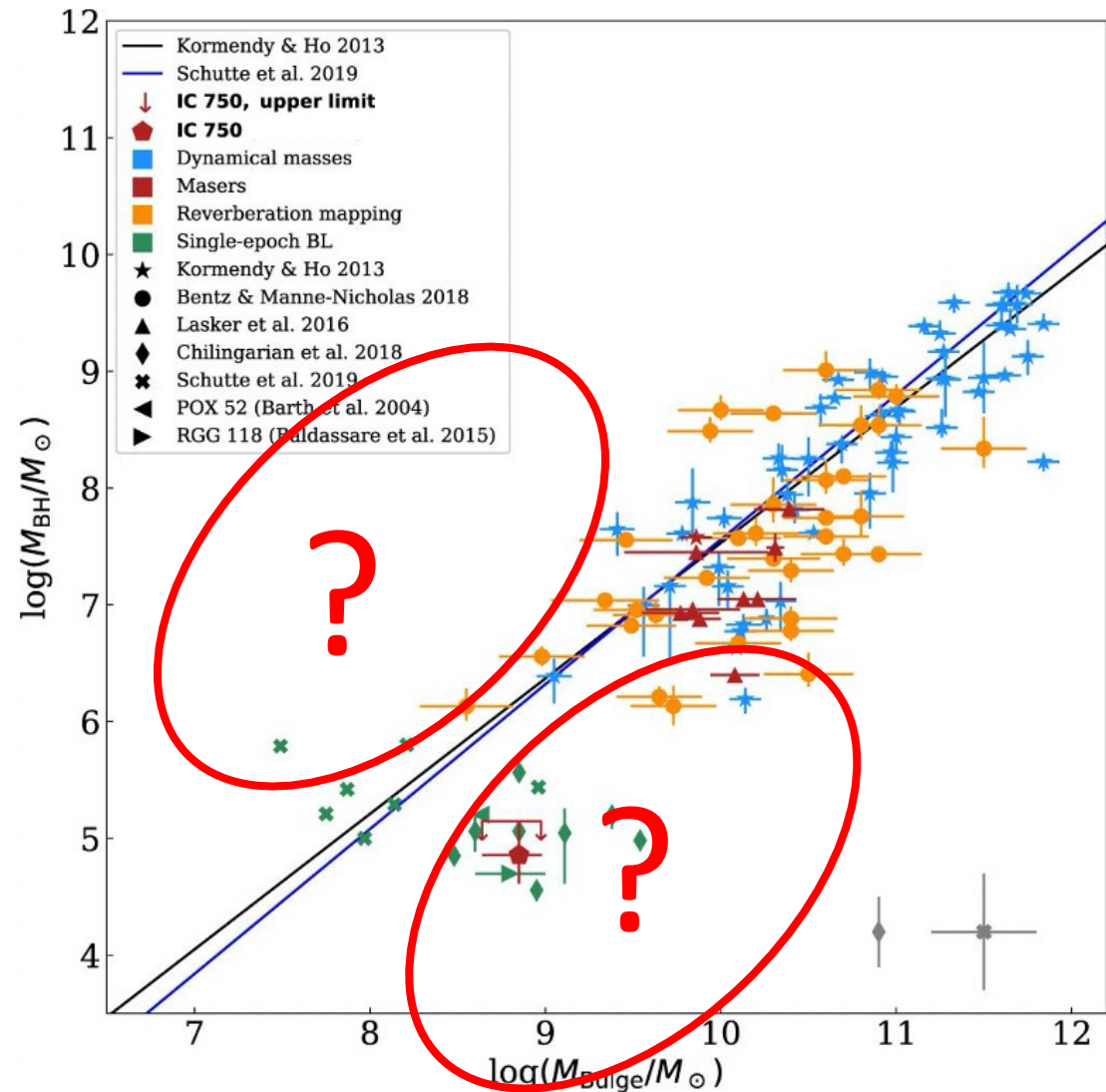
- We know at least one IMBH hosted by a nearby bulgeless galaxy – NGC 4395. How many similar objects do we lose because of selection?
- We know also opposite cases with bulges, which are more massive than expected from $M_{\text{BH}}-M_{\text{bulge}}$. These bulges are likely formed through the secular evolution

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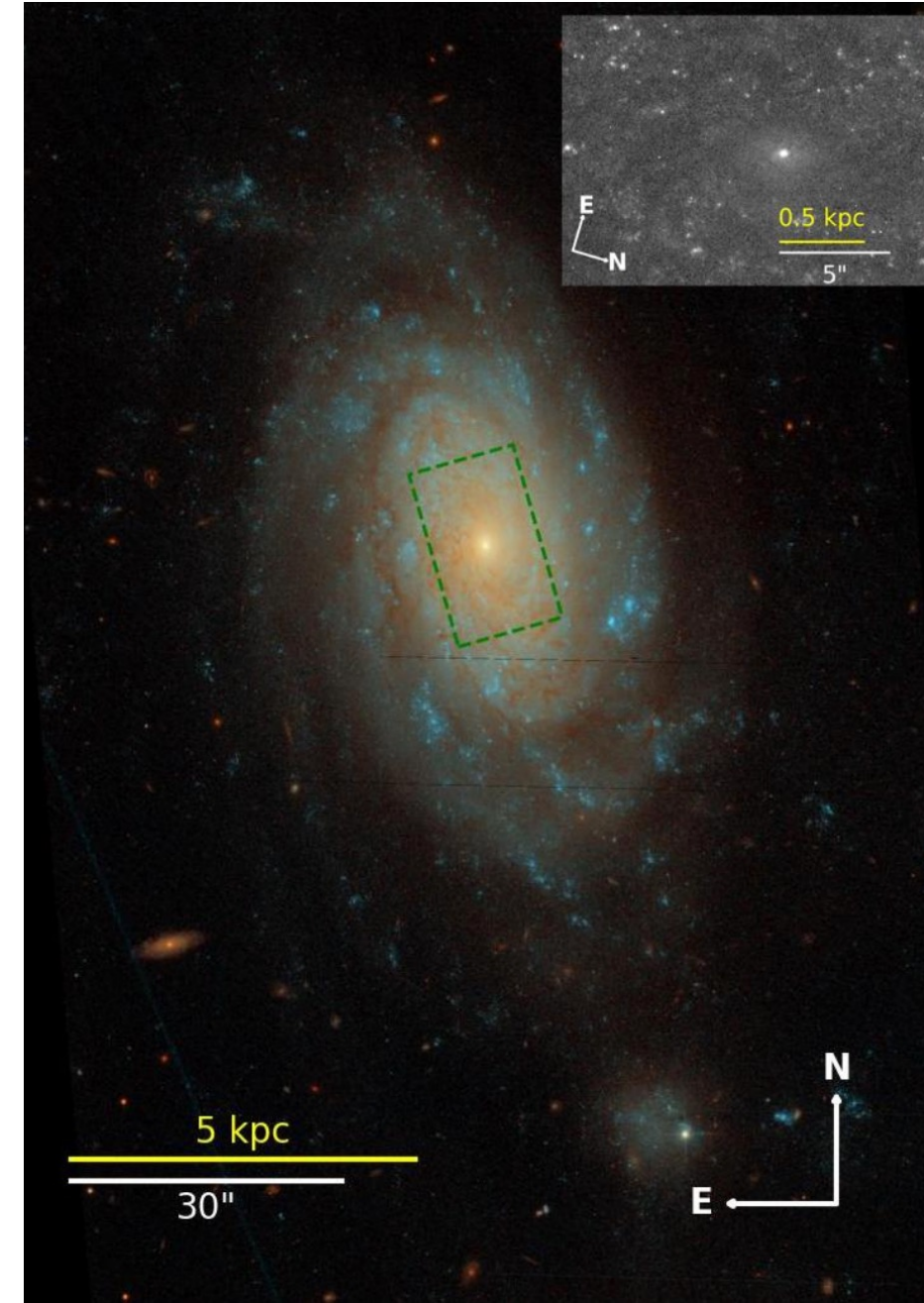
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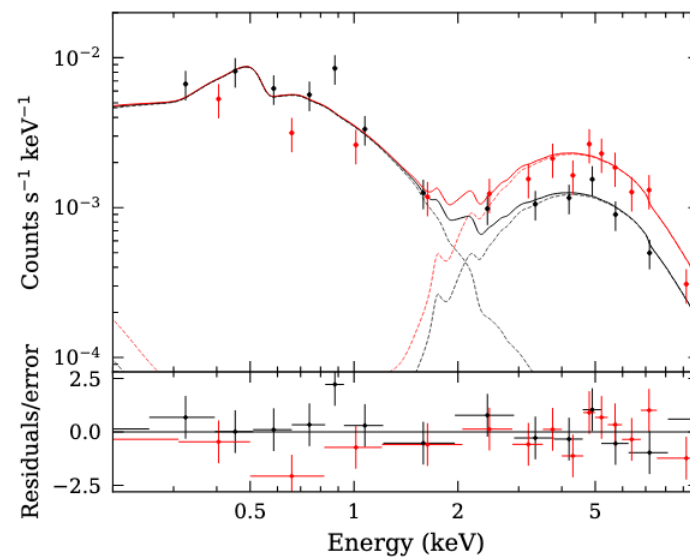
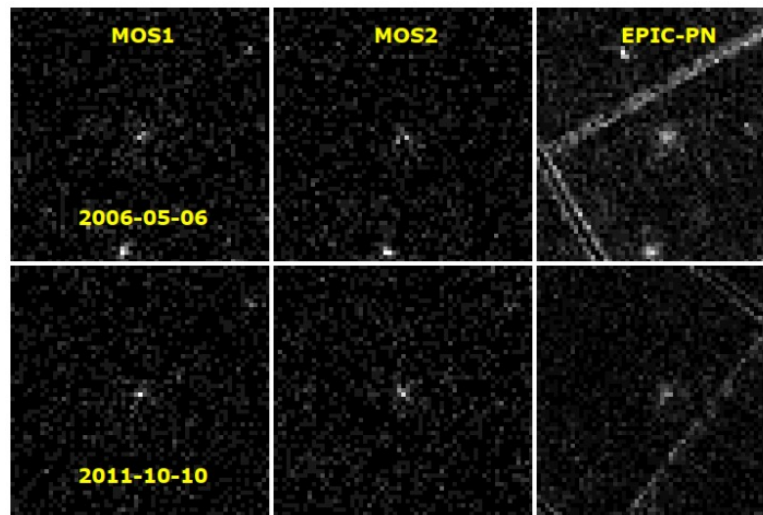
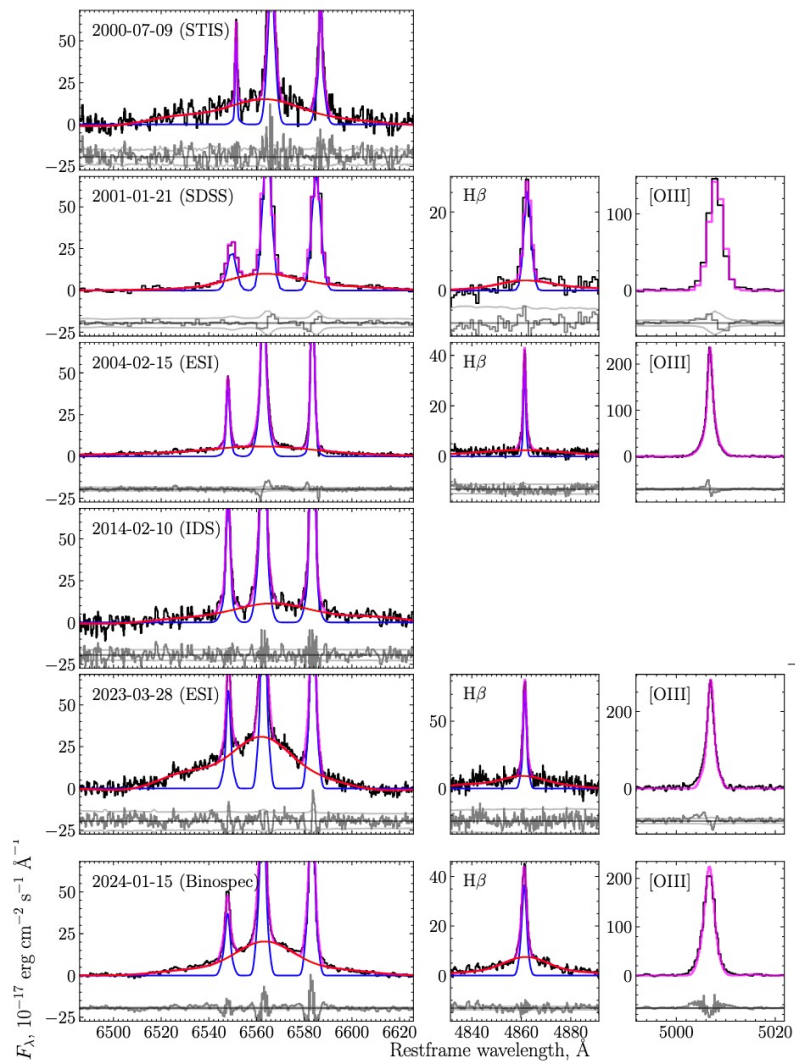


NGC 3259: a case-study of IMBH identification biases

(Grishin et al., 2025, A&A 702, A42)

- NGC 3259 is located in a very sparse group of galaxies at $D = 27$ Mpc
- $M_{\text{BH}} = (2.0\text{--}4.9) \times 10^5 M_{\odot}$
- Multi-epoch spectroscopic and X-ray observations
- Integral field unit (IFU) dataset with Binospec
- Low X-ray luminosity
- A perfect object for a case study of the biases in the detectability of galaxies with IMBHs





Multi-epoch
observations:
optical
spectra and X-
ray

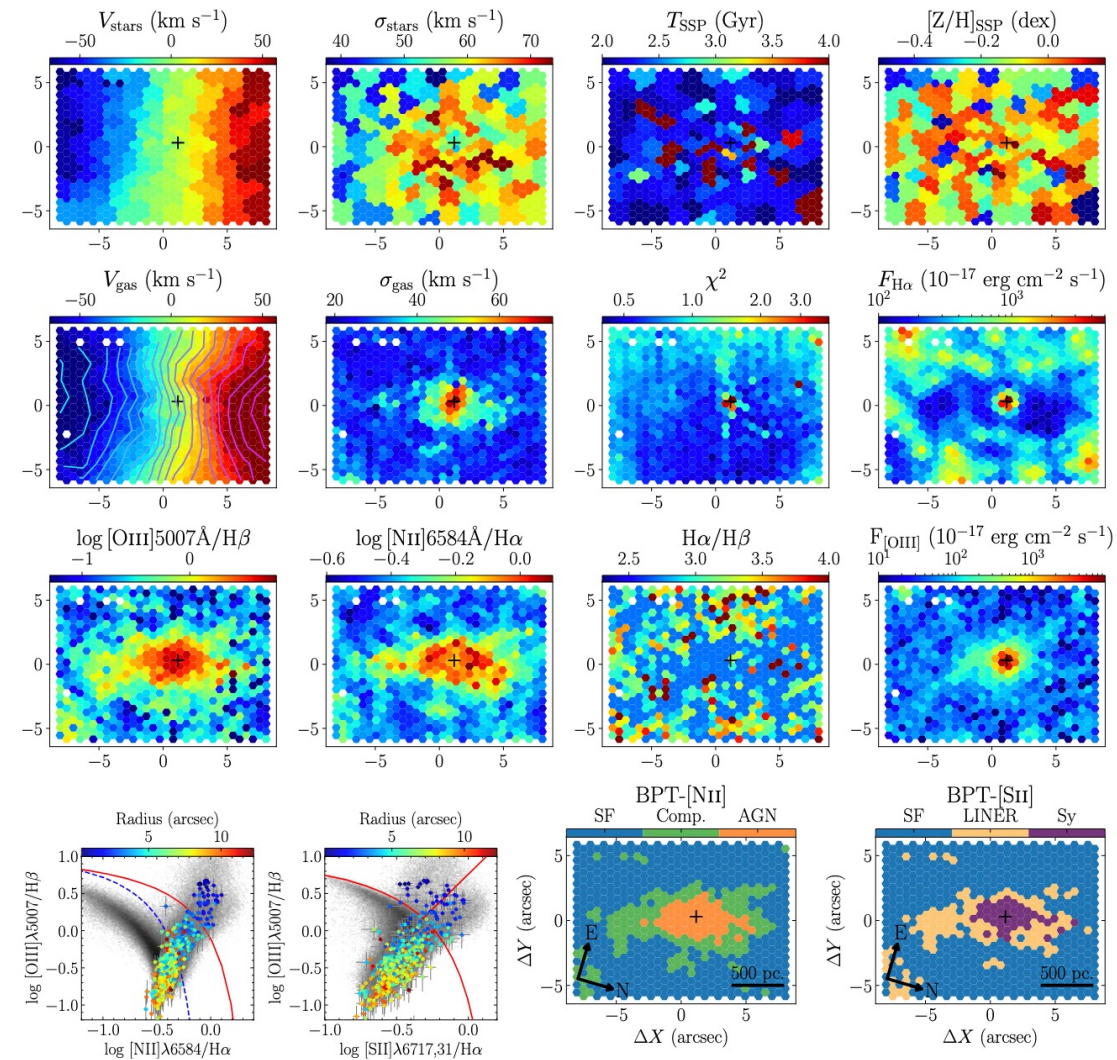
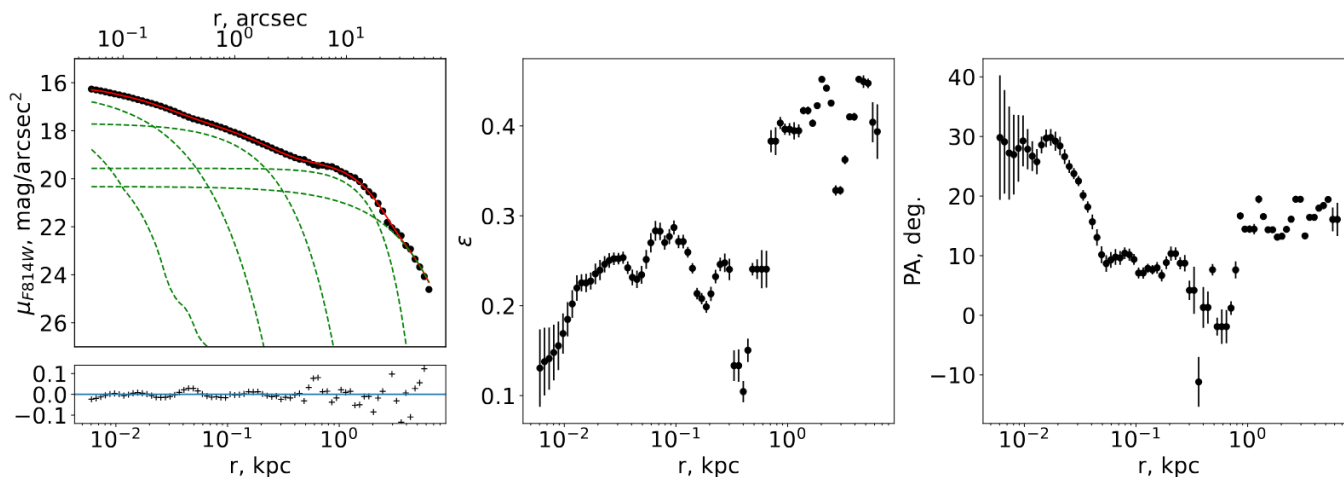
(Grishin et al., 2025, A&A
702, A42)

+ ongoing follow-up campaign with IFU

NGC 3259: central part

(Grishin et al., 2025, A&A 702, A42)

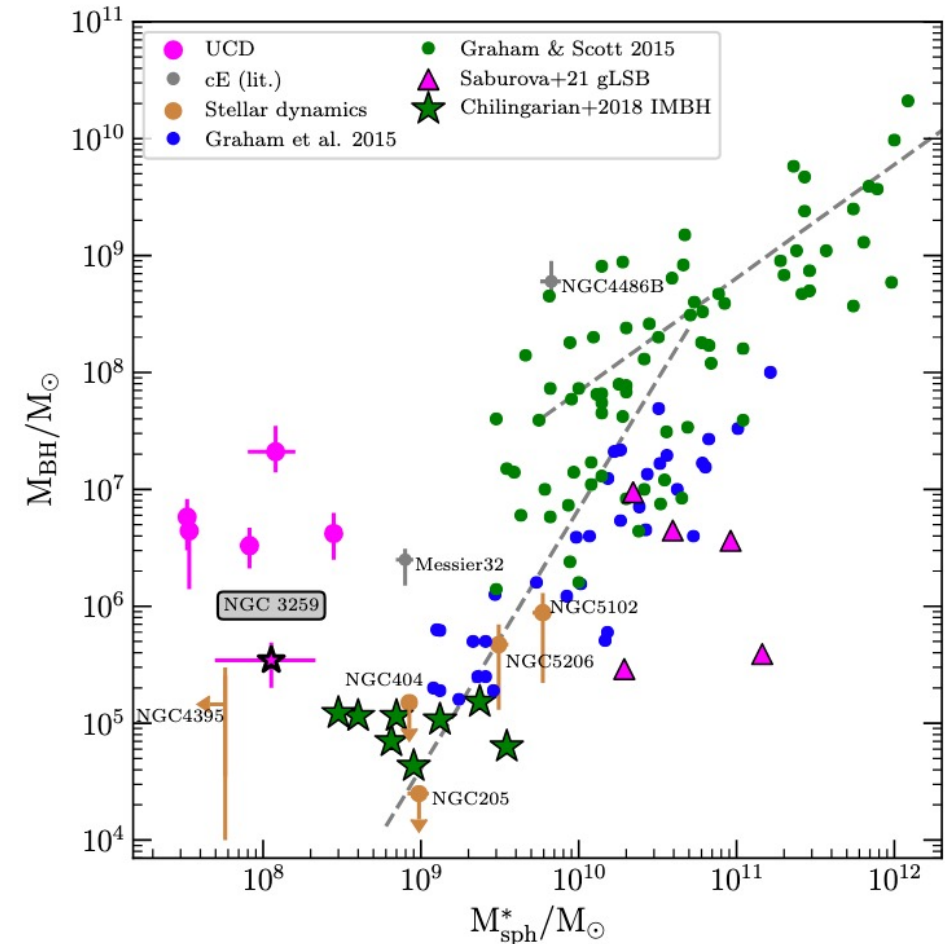
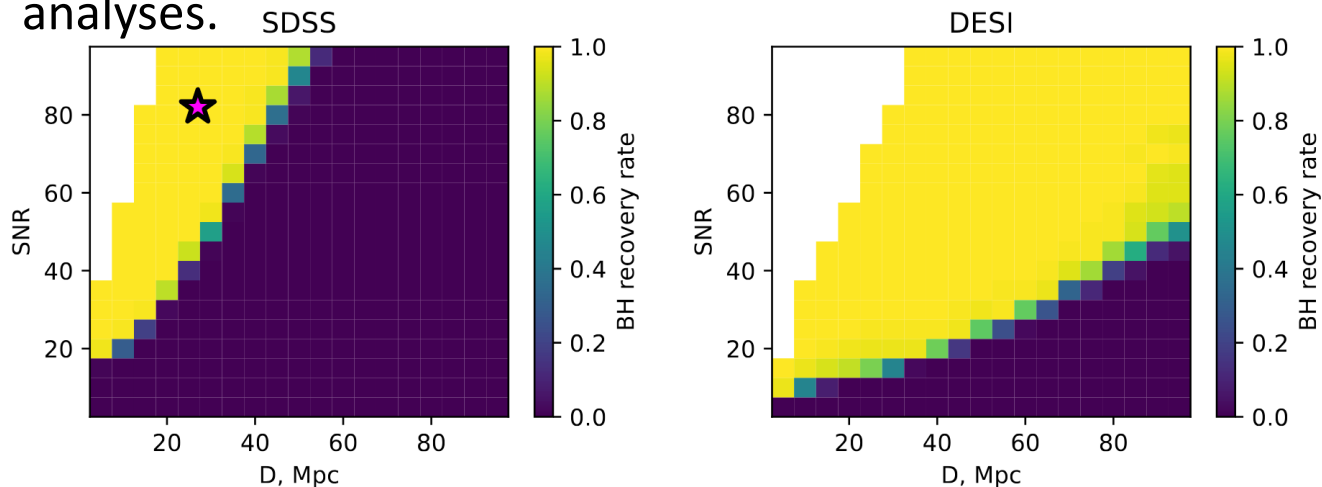
- NGC 3259 does not follow the $M_{\text{BH}} - M_{*,\text{bulge}}$ scaling relation, suggesting a dominant role of accretion in black hole growth and secular processes in pseudo-bulge evolution
- H α deficit in the inner 500 pc region may indicate the influence of a bar
- S-shaped isovelocity contours (isovels) are also consistent with bar-driven dynamics.
- However, infrared images show no clear signatures of a bar.



What do we learn from NGC 3259?

(Grishin et al., 2025, A&A 702, A42)

- In SDSS NGC 3259-like objects can be detected only to 40-50 Mpc
- With DESI the maximum distance would be 3.5–4 times larger, but one needs a S/N similar to SDSS per spaxel, which is usually not a case for DESI.
- Low accretion rate and, hence, low X-ray luminosity prevents it from identification in X-ray surveys like eRASS.
- In some cases, a low accretion rate and secular pseudo-bulge formation may be correlated — for example, through the presence of a bar — potentially introducing biases in sample analyses.



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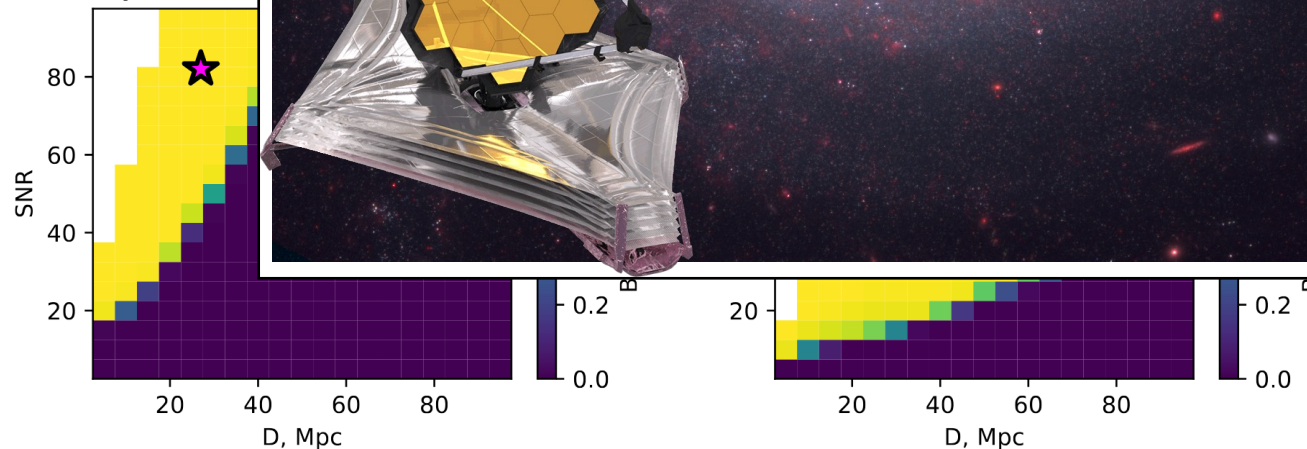
Mpc

- With DESI

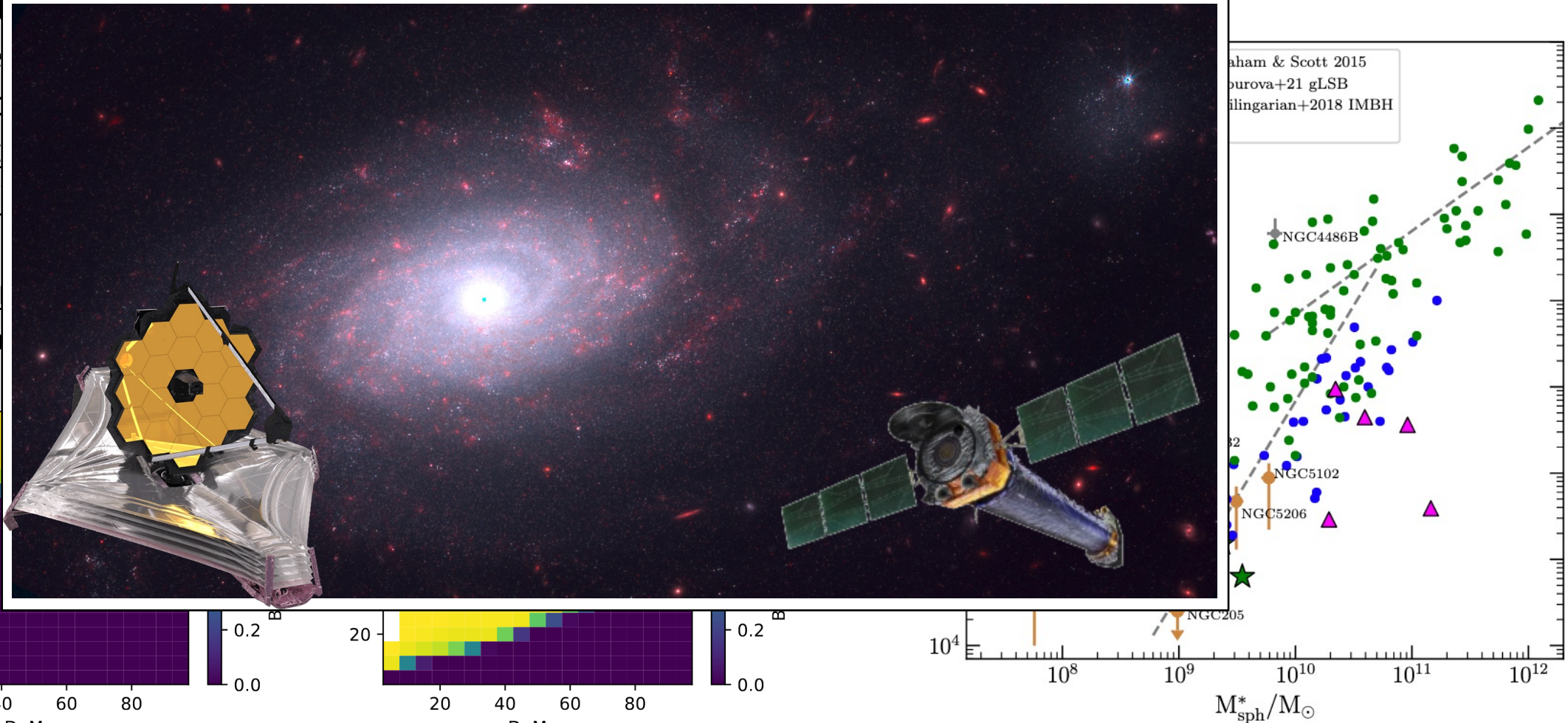
but one new
usually not

- Low accretion
from ident

- In some cases
formation
presence of
analyses.



New data: JWST+Chandra!



Conclusions

- Intensively accreting IMBHs and low-mass SMBH ($M_{\text{BH}} < 10^6 M_{\odot}$) tend to follow $M_{\text{BH}}\text{-}M_{\text{bulge}}$ scaling relation
- However, the location of currently observed IMBHs on the $M_{\text{BH}}\text{-}M_{\text{bulge}}$ does not immediately imply bulge-BH coevolution of all IMBHs as low accretion rate and the absence of bulge-BH may have the same reason, in case of NGC 3259 – potential presence of the bulge in the past
- Ongoing and future surveys, like DESI and 4MOST will drastically change this situation and substantially help us with the identification of low-accreting systems